COAL

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Probably the most important issues associated with the operation of the model steam locomotive and traction engine is the type of coal we burn. Coal has played a pivotal role in the progress of the Industrial Revolution. Without coal there would be no iron and steel and the development of the steam engine and steam turbine for electricity generation would have been delayed until the discovery of an alternative fuel. It is believed that the UK would have run out of water power by 1840. Coal saved the day.

Coal is a fossil fuel, the product of when the planet was warm and humid and covered in tropical rain forest some 100 to 400 million years ago. Immense pressure caused by the folding of the earth's surface compressed the decaying vegetable matter into coal.

Coal is found widely throughout the planet. There are rich deposits under Greenland and Siberia. They mine coal in Spitsbergen and the German battleship Scharnhorst shelled Spitsbergen in 1942 setting fire to a coal mine that continued to burn until the early 1990s. It is interesting to note that those regions today enjoy an Arctic climate whereas in the geological past they were tropical rain forest.

The USA has 25% of the world's reserves of coal and under the UK there are deep reserves that could hold enough coal for around 200 years supply. So for us model engineers there is no shortage of coal in the foreseeable future the problem is finding the variety of coal best suited to the combustion conditions in our boilers.

The quality and variety of coal varies widely from the low grade lignite with a carbon content of 60-75% and volatiles of 45-65% to the high quality anthracites with a carbon content greater than 92% and low volatiles of 7-12%. Coal is broadly grouped into three categories; anthracite, bituminous, and lignite. "Steam coal" is a bituminous coal.

The best anthracites come from the USA with carbon content as high as 97% and volatiles less than 6%. The higher the carbon content the greater the calorific value (CV) or heat content per unit volume and the lower the volatiles the less smoke and soot they produce.

Bituminous coal covers a wide range of coal varieties. At the low carbon end of the range the coal has a carbon content of greater than 75% up to the "steam

coals" with a maximum carbon content of nearly 90%. The CV increases with increasing carbon content. Steam coal burns with a long yellow flame and, depending on the volatiles content, considerable amounts of smoke.

Bituminous coals are used for a wide range of applications ranging from coke production, iron ore smelting, the production of chemical by-products (phenol, bitumen etc), pulverised coal firing of power station boilers, towns gas, main line steam locomotives and household fires. When burnt, bituminous coals have a caking characteristic whereby the coal fuses into larger lumps. If the caking is not frequently broken up insufficient air can pass through the fire bed resulting in a reduction in steam generation. Also, the caking combined with a higher ash content and mineral impurity content in the high temperatures generated in a model locomotive fire box can lead to excessive clinker formation.

The name "steam coal" is misleading since it gives the impression that it is the best coal for steam raising. That is incorrect. The reason for the title "steam coal" comes from the early part of the Industrial Revolution, when it was found that the coal from certain pits burnt freely in natural draught boilers with lesser amounts of smoke and soot than lower grade bituminous coals and had good heat characteristics because their carbon content was at the upper end of

Photo Colin Gross

Anthracite is hard and often has almost glass like surfaces.

Steam Coal is crumbly with a matt dusty surface.

the bituminous range. The Royal Navy favoured these coals for coal fired warships and thus they became known as "steam coal". These coals come mainly from the Rhonda Valley in South Wales. There is no clear specification for steam coal, at the low end they are close to household coal with high volatiles and ash and they clinker easily due to their low ash fusion temperature. They also contain significant quantities or mineral impurities. At the upper end of the range they are close to anthracites.

The quality and availability of coal had a major effect on the development of the steam locomotive. The Great Western had access to the "steam coal" of South Wales whilst the other companies had to contend with lower grade coal from the Midlands, Yorkshire, Kent, Northumberland, Durham and Scotland. It was Ivatt on the Great Northern that pioneered the use of the wide firebox on his Atlantics and continued by Gresley on his Pacifics. Stanier quickly realised, when he became the CME of the LMS, that he could only achieve the combustion rate needed for his Princess Royal and Coronation Pacifics burning lower grade coals by employing a wide firebox. Bullied (ex Gresley assistant) CME of the SR, who had to rely on poor grade coal from the Kent coal field, designed a wide firebox boiler for his Merchant Navy, West Country, and Battle of Britain classes that would burn almost anything and still maintain a high steaming rate. The Great Western, because of the availability of good coal, stayed with the narrow firebox even with the Kings which had a tractive effort equal to any of the locomotives subsequently designed by all the other CMEs. When Peppercorn designed the A1s in 1947 he increased the size of the Gresley firebox to burn the poor grade coals which had become even poorer on the post war LNER.

Under nationalisation in 1948 when Riddles (ex LMS) became the CME of BR, the trend towards the wide firebox continued and all locomotives with a power classification higher than five sensibly had wide fireboxes and were, therefore, less sensitive to coal quality.

Anthracite is quite different from "steam coal". It is high in carbon, low in volatiles, ash and mineral impurities and has a high ash fusion temperature. It is sometimes difficult to ignite, it requires a strong draught to burn, it burns with a bluish short flame, it produces little or no smoke and has the highest CV of all the coals. It has a bright shiny appearance and can be handled without making your hands dirty. The best anthracite mined in the UK by Celtic Energy is known as "black diamond". In the UK anthracite is exclusive to West Wales, the further west the higher the quality.

Our small steam locomotives are sensitive to the type of coal we burn and the way in which we manage the fire. Clinkered grates will soon reduce the boiler steaming rate. High ash content requires frequent ash pan and smoke box emptying and excessive smoke and soot is unpleasant for the passengers. However the model steam locomotive has strong draughting characteristics both moving and stationary and this together with the higher calorific value favours the burning of anthracite.

The way in which we manage our fire also has a significant effect upon the boilers ability to steam freely. All bituminous coals (they contain bitumen) have a "caking" characteristic. The "cake" needs to be frequently broken up

and the fire regularly raked. Anthracite burns differently. It does not "cake". As the coal burns the lumps of coal disintegrate into smaller and smaller pieces until, due to their low ash content, there is little residue. Fires burning anthracite require very little raking and just an occasional pricking to break up any slight clinkering.

Fire bar spacing also has an effect on how the fire burns. Generally, spacing (or air gap) is between 6mm to 8mm. My C19 is spaced at 6mm because I normally burn anthracite. If burning "steam coal" a wider spacing is preferred due to the higher ash and clinker formation.

Photo Colin Gross

Pieces of clinker, which will form a solid layer over the grate and stifle the fire if not raked out.

A hypothetical specification for a coal to be burnt in a model steam locomotive would be: highest possible calorific value (heat per unit volume), low smoke and soot, lowest possible ash, minimum clinker and clean handling with minimum dust. So, matching the fuel to the locomotive comes out strongly in favour of anthracite.

It is important that we know the source of the coal we burn so that we can maintain stocks of the right coal. Despite large reserves of coal under the UK a large proportion of coal sold in the UK is imported in bulk and then bagged in the UK. Invariably, its country of origin and quality remains a mystery.